

What Is Claimed Is:

1. A brushless DC motor comprising  
an armature assembly; and  
a field assembly, including  
a plurality of permanent magnets each having a length; and  
a plurality of pole pieces each having a length; and  
wherein the ratio between the length of the plurality of permanent magnets  
and the length of the plurality of pole pieces is tailored to achieve a constant  
force versus stroke characteristic.
2. A brushless DC motor comprising  
an armature assembly; and  
a field assembly positioned with respect to the armature assembly so that  
an air gap is formed between them, including  
a plurality of permanent magnets each having a length; and  
a plurality of pole pieces each having a length; and  
wherein the ratio between the length of the plurality of permanent magnets  
and the length of the plurality of pole pieces is selected to provide a sinusoidal  
distribution of a normal component of flux density in the air gap.
3. The brushless DC motor of claims 1 or 2, further including  
a housing comprising magnetic material; and  
end caps including end pole pieces having a length, and positioned on the  
field assembly so that the field assembly, the end caps and the housing form a  
common magnetic circuit; and  
wherein the ratio of the length of the end pole pieces to the length of the  
plurality of pole pieces is selected so that a sinusoidal force versus entire stroke  
characteristic is obtained for the brushless DC motor.
4. The brushless DC motor of claims 1 or 2 wherein the plurality of permanent  
magnets and the plurality of pole pieces are positioned along a common field assembly

axis, and so that each of the plurality of permanent magnets is separated from another by different ones of the plurality of pole pieces.

5        5. The brushless DC motor of claim 3 wherein the length of each of the plurality of pole pieces is two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

10       6. The brushless DC motor of claim 4 wherein the length of each of the plurality of pole pieces is two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

15       7. The brushless DC motor of claim 3 wherein the length of each of the end pole pieces is one half ( $1/2$ ) the length of each of the plurality of pole pieces.

20       8. The brushless DC motor of claim 4 wherein the length of each of the end pole pieces is one half ( $1/2$ ) the length of each of the plurality of pole pieces.

25       9. The brushless DC motor of claim 5 wherein the length of each of the end pole pieces is one half ( $1/2$ ) the length of each of the plurality of pole pieces.

30       10. The brushless DC motor of claim 6 wherein the length of each of the end pole pieces is one half ( $1/2$ ) the length of each of the plurality of pole pieces.

35       11. The brushless DC motor of claims 1 or 2 wherein the armature assembly includes a non-magnetic coil base, and a plurality of coils supported on the non-magnetic coil base.

40       12. The brushless DC motor of claim 11 wherein the plurality of coils form a three (3) phase winding.

13. A linear motion device, comprising  
a field assembly, including

a plurality of pole pieces;  
a plurality of end pole pieces; and  
a plurality of permanent magnets;

wherein the plurality of pole pieces, the plurality of end pole pieces, and the plurality of permanent magnets are positioned along a common axis so that ones of the plurality of pole pieces are positioned between ones of the plurality of permanent magnets;

a housing positioned about the field assembly to form a common magnetic circuit with the field assembly;

an armature assembly adapted to travel along the common axis, and positioned between the housing and the field assembly to define a gap between the armature assembly and the field assembly, the armature assembly including

a non-magnetic coil base;  
a plurality of coils supported on the non-magnetic coil base; and

further wherein each of the plurality of permanent magnets has a length and polarity and each of the plurality of pole pieces and plurality of end pole pieces has a length which are selected so that the field assembly provides a constant force versus stoke characteristic and a sinusoidal distribution of a normal component of the flux density in the gap.

14. The linear motion device of claim 13, wherein the length of each of the plurality of pole pieces is two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

15. The linear motion device of claim 13 wherein the length of each of the end pole pieces is one half ( $1/2$ ) the length of each of the plurality of pole pieces.

16. A method of forming a brushless DC motor having an armature assembly and a field assembly, comprising the steps of

positioning a plurality of permanent magnets each having a length along a common field assembly axis;

positioning a plurality of pole pieces each having a length along the common field assembly axis, and so that ones of the plurality of pole pieces alternate with ones of the plurality of permanent magnets; and

selecting the ratio between the length of the plurality of permanent magnets and the length of the plurality of pole pieces to achieve a sinusoidal force versus stroke characteristic, when only one phase or a combination of two phases of the armature are energized.

17. The method of claim 16, further including the step of positioning the field assembly with respect to the armature assembly so that an air gap is formed between them, and further wherein the selecting step includes

setting the ratio between the length of the plurality of permanent magnets and the length of the plurality of pole pieces to provide a sinusoidal distribution of a normal component of flux density in the air gap.

18. The method of claims 16 or 17, further including the steps of providing a housing formed of magnetic material;

providing end caps including end pole pieces having a length, and positioning the housing and the end caps and the field assembly so that the field assembly, the end caps and the housing form a common magnetic circuit; and

adjusting the ratio of the length of the end pole pieces to the length of the plurality of pole pieces so that a sinusoidal force versus entire stroke characteristic is obtained for the brushless DC motor.

19. The method of claims 16 or 17 wherein the selecting step includes the step of setting the length of each of the plurality of pole pieces to be two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

20. The method of claim 18 wherein the adjusting step includes the step of setting the length of each of the plurality of pole pieces to be two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

5        21. The method of claim 18 wherein the adjusting step includes the step of setting the length of each of the end pole pieces to be one half ( $1/2$ ) the length of each of the plurality of pole pieces.

10        22. The method of claims 16 or 17 further including the step of forming the armature assembly of a non-magnetic coil base, and a plurality of coils supported on the non-magnetic coil base.

15        23. The method of claim 22 wherein the step of forming the armature assembly step includes the step of forming a three (3) phase winding from the plurality of coils.

20        24. A method of forming a linear motion device, comprising the steps of forming a field assembly of a plurality of pole pieces; a plurality of end pole pieces; and a plurality of permanent magnets;

25        positioning the plurality of pole pieces, the plurality of end pole pieces, and the plurality of permanent magnets along a common axis so that ones of the plurality of pole pieces are positioned between ones of the plurality of permanent magnets;

30        positioning a housing about the field assembly to form a common magnetic circuit with the field assembly;

35        supporting a plurality of coils supported on a non-magnetic coil base to form an armature assembly;

40        positioning the armature assembly to be adapted to travel along the common axis between the housing and the field assembly and to define a gap between the armature assembly and the field assembly, and

45        selecting a length and polarity of each of the plurality of permanent magnets, a length and polarity of each of the plurality of pole pieces, and length

and polarity of each of the plurality of end pole pieces so that the field assembly provides a constant force versus stoke characteristic and a sinusoidal distribution of a normal component of the flux density in the gap.

5           25. The method of claim 24, wherein the selecting step includes the step of setting the length of each of the plurality of pole pieces to be two-thirds ( $2/3$ ) the length of each of the plurality of permanent magnets.

10           26. The method of claim 24, wherein the selecting step includes the step of setting the length of each of the end pole pieces to be one half ( $1/2$ ) the length of each of the plurality of pole pieces.

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